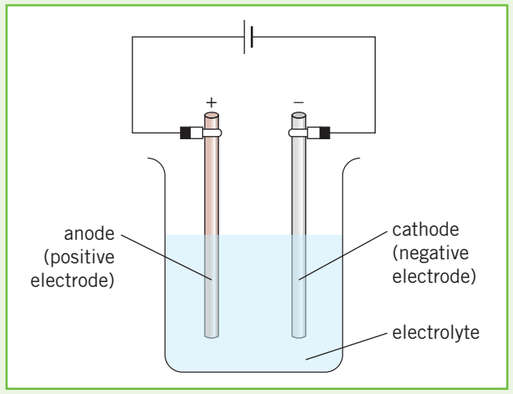
Chapter 6: Electrolysis

Knowledge organiser

Electrolysis

In the process of **electrolysis**, an electric current is passed through an **electrolyte**. An electrolyte is a liquid or solution that contains ions and so can conduct electricity. This causes the ions to move to the **electrodes**, where they form pure elements.



Electrolysis of molten compounds

Solid ionic compounds do not conduct electricity as the ions cannot move. To undergo electrolysis they must be molten or dissolved, so the ions are free to move.

When an ionic compound is molten:

- The positive metal ions are *attracted* to the **cathode**, where they will *gain* electrons to form the pure metal
- The negative non-metal ions are *attracted* to the **anode**, where they will *lose* electrons and become the pure non-metal.

For example, molten sodium chloride, $NaCl$, can undergo electrolysis to form sodium at the cathode and chlorine at the anode.

Half equations (HT only)

sodium chloride → sodium + chlorine

$2NaCl(l) \rightarrow 2Na(s) + Cl_2(g)$

- at the cathode:

  $2Na^+(l) + 2e^- \rightarrow 2Na(s)$
- at the anode:

  $2Cl^-(l) \rightarrow Cl_2(g) + 2e^-$

Electrolysis of aqueous solutions

Solid ionic compounds can also undergo electrolysis when dissolved in water.

- It requires less energy to dissolve ionic compounds in water than it does to melt them.
- However, in the electrolysis of solutions, the pure elements are not always produced. This is because the water can also undergo ionisation:

$$H_2O(l) \rightarrow H^+(aq) + OH^-(aq)$$

Products at the anode

In In the electrolysis of a solution, if the non-metal contains oxygen then oxygen gas is formed at the anode:

- The $OH^-(aq)$ ions formed from the ionisation of water are attracted to the anode.
- The $OH^-(aq)$ ions lose electrons to the anode and form oxygen gas.
- $4OH^-(aq) \rightarrow O_2(g) + 2H_2O(l) + 4e^-$

If the non-metal ion is a halogen, then the halogen gas is formed at the anode.

- $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

potassium
sodium
calcium
magnesium
aluminium
(carbon)
zinc
iron
tin
lead
(hydrogen)
copper
silver
gold
platinum

most reactive

least reactive

Products at the cathode

In the electrolysis of a solution, if the metal is *more* **reactive** than hydrogen then hydrogen gas is formed at the cathode:

- The $H^+(aq)$ ions from the ionisation of water are attracted to the cathode and react with it.
- The $H^+(aq)$ ions gain electrons from the cathode and form hydrogen gas.
- $2H^+(aq) + 2e^- \rightarrow H_2(g)$
- The metal ions remain in solution.

Electrolysis of aluminium oxide

Electrolysis can be used to extract metals from their ionic compounds.

Electrolysis is used if the metal is more reactive than carbon.

Aluminium is extracted from aluminium oxide by electrolysis.

1 The aluminium oxide is mixed with a substance called **cryolite**, which lowers the melting point.
2 The mixture is then heated until it is molten.
3 The resulting molten mixture undergoes electrolysis.

aluminium oxide → *aluminium* + *oxygen*

$2Al_2O_3(l) \rightarrow 4Al(l) + 3O_2(g)$

cathode: pure aluminium is formed

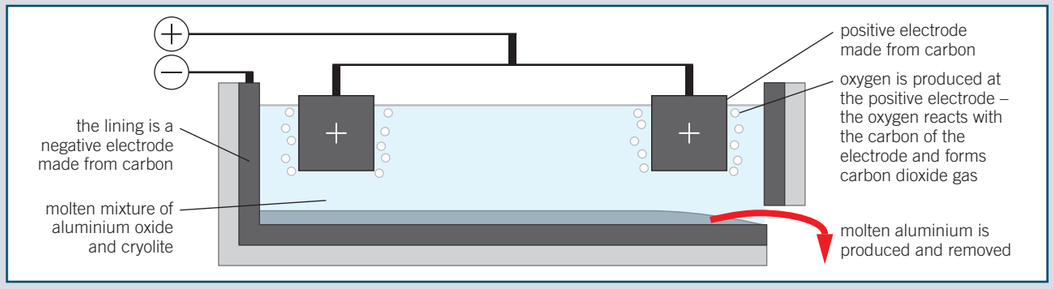
$Al^{3+}(l) + 3e^- \rightarrow Al(l)$

anode: oxygen is formed

$2O^{2-}(l) \rightarrow O_2(g) + 4e^-$

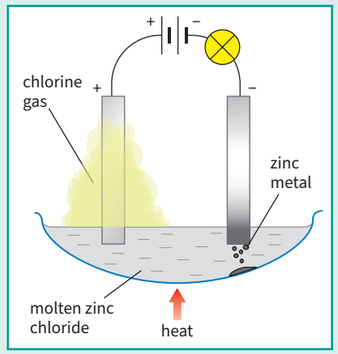
In the electrolysis of aluminium, the anode is made of graphite.

The graphite reacts with the oxygen to form carbon dioxide and so slowly wears away. It therefore needs to be replaced frequently.



Electrolysis of zinc chloride

Molten zinc chloride is broken down by electrolysis. This means zinc metal is collected at the cathode and a pale green chlorine gas is collected at the anode. Free ions from the molten zinc chloride are able to move around and carry electric currents, hence why the bulb lights up.



Key terms

Make sure you can write a definition for these key terms.

anode *cathode* *cryolite* *electrode* *electrolysis* *electrolyte* *reactivity*